

U.S. States and Territories National Tsunami Hazard Assessment: Review and Update

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In 2007, the NOAA/National Geophysical Data Center (NGDC) and the U.S. Geological Survey (USGS) conducted the first U.S. tsunami hazard assessment, titled “U.S. States and Territories National Tsunami Hazard Assessment: Historical Record and Sources for Waves”, Dunbar and Weaver (2008). The goal of the report was to provide a qualitative assessment of the tsunami hazard at the national level. Since 2007, several tsunamis have affected the U.S. and new tsunami research has been published prompting an effort to review and update the assessment.

The first assessment was written in response to a joint report by the sub-committee on Disaster Reduction and the U.S. Group on Earth Observations entitled *Tsunami Risk Reduction for the United States: A Framework for Action*. The first specific action called for in the *Framework* was to “Develop standardized and coordinated tsunami hazard and risk assessments for all coastal regions of the United States and its territories.” The National Tsunami Hazard Mitigation Program (NTHMP), a partnership between Federal and State agencies, provides the organizational framework needed to execute this tsunami initiative. Since the National Oceanic and Atmospheric Administration (NOAA) is the lead agency for providing tsunami forecasts and warnings, the NTHMP requested that NOAA take the lead in conducting the first national tsunami hazard assessment.

The first step in a tsunami hazard assessment is to examine the past record since it provides clues to what might happen in the future. NOAA’s National Geophysical Data Center (NGDC) catalogs information on global historical tsunamis. Earthquakes or earthquake-generated landslides caused more than 85 percent of the tsunamis listed in the NGDC tsunami database, with the remainder due to volcanic eruptions, non-earthquake generated landslides, and other sources. The United States Geological Survey (USGS) conducts research on earthquake hazards facing all of the United States and its territories. Therefore, NOAA/NGDC and USGS collaborated to conduct the first tsunami hazard assessment of the United States and its territories for the NTHMP. The goal was to provide a national qualitative assessment of the United States tsunami hazard at a regional level by examining the record of historical tsunamis and earthquakes, the predominant cause of tsunamis, at the State and territory level.

Two different sources of information were compiled to assess the U.S. tsunami hazard. The first involved a careful examination of the NGDC historical tsunami database which resulted in a qualitative tsunami assessment based on the distribution of runup heights and the frequency of tsunami runups. The tsunami hazard was characterized by first determining the number of individual tsunamis reported in each State or territory and then binning the results into five categories of runup amplitudes—Undetermined runup height, 0.01 m to 0.5 m, 0.51 m to 1.0 m, 1.01 m to 3.0 m, and greater than 3.0 m. Based on the total spread of events, runup amplitudes, and earthquake potential, a subjective hazard was assigned from very low to very high. These assessments recognized that tsunami runups of a few tens of centimeters have a lower hazard than those with runups of a few to many meters.

Although tsunami deaths are a measure of risk rather than hazard, the known tsunami deaths found in the NGDC database search were compared with the qualitative assessments based on frequency and amplitude. There were no known deaths from tsunamis along the U.S. Atlantic coast or Gulf coast and only one known death in the Pacific territories (on Guam). In contrast, both Alaska and Hawaii have unfortunately experienced several hundred deaths each from tsunamis. Tsunamis in Puerto Rico and the U.S. Virgin Islands have caused a total of 172 deaths. The U.S. west coast has had 25 tsunami deaths, but due to the lack of written records, there are no estimates of deaths caused by the great Cascadia earthquake in 1700. There is evidence from oral traditions and computer simulations that this event must have severely impacted native populations.

The NGDC tsunami database contains *reported* tsunamis and is therefore limited to written records existing for an area. The hazard assessment used the USGS National Seismic Hazard Map (NSHM) databases to partially extend the time interval. These databases are primarily meant to assess earthquakes affecting U.S. possessions and do not include all possible seismogenic tsunami sources in the Pacific and Atlantic Basins. However, the databases make it possible to estimate the rate of occurrence of larger magnitude earthquakes that could generate a tsunami. The USGS NSHM databases are based on tectonic models, and paleoseismic and paleotsunami data. It is important to understand that the USGS NSHM databases are used to calculate earthquake, not tsunami, occurrence. Along the U.S. Pacific and the Caribbean coastlines, the rate of the largest magnitude local subduction zone earthquakes calculated by the USGS is essentially the same as the rate of nearshore tsunami generation, because great (>M7.5 to 8.0) subduction zone earthquakes are the most common cause of tsunamis along these coastlines. This is not the case along the Atlantic or Gulf coasts, where very limited experience suggests that the occurrence of a large earthquake does not necessarily mean a tsunami is generated.

The following table summarizes the results of the NGDC and USGS database searches from the 2007 assessment.

Table A. Qualitative tsunami hazard assessment based on NGDC and USGS databases.

<i>Region</i>	<i>Hazard based on runups</i>	<i>Hazard based on frequency</i>	<i>Hazard based on local earthquakes</i>	<i>Number of reported deaths</i>
U.S. Atlantic coast	Very low to low	Very low	Very low to low	None
U.S. Gulf coast	Very low	Very low	Very low	None
Puerto Rico and the Virgin Islands	High	High	High	172
U.S. west coast	High	High	High	25
Alaska	Very high	Very high	High	222
Hawaii	Very high	Very high	High	326
U.S. Pacific island territories	Moderate	High	High	1

Since the 2007 assessment, there have been 21 tsunami events that have affected the U.S. States and Territories. One tsunami was observed on the U.S. East coast and a small tsunami was registered on tide gauges in Puerto Rico and the U.S. Virgin Islands from the 2010 Haiti earthquake. The remaining tsunami events were generated by earthquakes and volcanic eruptions in the Pacific Basin. Of these observations, a 3.6 m runup in Boothbay Harbor, Maine, was observed after a tsunami with an unknown cause in 2008. There were 169 field survey measurements >3 m and 46 runups of 1-3 m on American Samoa from the 2009 Samoa tsunami. The 2010 Chile tsunami caused a 1.2 m runup in Pismo Beach, California. The 2011 Tohoku tsunami generated 1-3 m runups in Alaska, California, Hawaii, Oregon, and the Northern Mariana Islands. The 2009 Samoa tsunami was the mostly deadly and costly event to affect the U.S., with 34 deaths and \$125.5 million damage reported in American Samoa. The 2010 Chile tsunami caused over \$3

million damage to boat harbors in California. The 2011 Tohoku, Japan, tsunami resulted in additional damage to California boat harbors (\$70.9 million), one death in Klamath River, California; and \$30.6 million damage in Hawaii. Based on the tsunami effects observed in the U.S. since the last assessment, the qualitative tsunami hazard assessment for The U.S. Pacific Island territories should be changed from “Moderate” to “High”.

Section 4 of the first assessment discussed gaps in the knowledge of tsunamis sources. New research results should be considered in the updated tsunami hazard assessment. For example, Goldfinger et al. (2012) tested the Holocene turbidite record as a paleoseismic record for the Cascadia subduction zone, Abadie et al. (2011) modeled tsunami waves generated by the flank collapse of the Cumbre Vieja Volcano, Grilli et al. (2008) examined the submarine landslide tsunami hazard along the upper east coast of the United States, and ten Brink et al. (2008) evaluated tsunami sources with the potential to impact the U.S. Atlantic and Gulf coasts. The USGS National Seismic Hazard Map is being revised and the latest version will be used in conducting the earthquake database searches.

References

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